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Combining surveys and on-line searching volumes to analyze public awareness about invasive alien species: a case study with the invasive Asian yellow-legged hornet (*Vespa velutina*) in Italy

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Abstract

The Asian yellow-legged hornet (*Vespa velutina*) has been invading Italy since 2013, and it was subjected to management programs to counter its spread and raise awareness about its impacts. We administered a questionnaire to a sample of 358 beekeepers in Italy, asking them about their sources of information on *V. velutina* and their perception of its potential impacts and severity, compared to other threats to beekeeping. We also explored Internet searching volumes on Google and Wikipedia about *V. velutina*, to identify seasonal and long-term trends in public awareness. Workshops, journals or bulletins, the Internet and word-of-mouth with colleagues were the primary sources of information about *V. velutina*. Internet searches peaked during the activity period of the species and increased over time, with thousands of visits to Wikipedia each month. Beekeepers believed *V. velutina* to affect beekeeping by predating on honey bees (*Apis mellifera*), paralyzing foraging, reducing honey availability and depleting the winter cluster. Moreover, *V. velutina* has been deemed a severe threat to beekeeping, similar to other threats like pesticides and the varroa mite (*Varroa destructor*). Our findings indicate that beekeepers seem to be aware of the potential impacts of *V. velutina* in Italy, both within and outside of its invaded area, considering it a major threat to beekeeping. Moreover, citizens seem to have become progressively curious about the species. Information campaigns on the Internet and specialized magazines might be helpful to communicate about the impacts of the species, and the need to develop diffused surveillance networks.

Keywords
Beekeeping, biological invasions, Google, Google Trends, species management, Wikipedia

Introduction

Biological invasions are a major driver of change globally, with environmental and socio-economic impacts, whose frequency and magnitude are increasing in synergy with international trade and climate change (Hulme 2009; Robinson et al. 2020). Therefore, many countries have developed public policies aimed at preventing, counteracting, or mitigating biological invasions (Turbelin et al. 2017), including both dedicated legal frameworks and also financial support for specific conservation projects targeting invasive alien species (e.g. the LIFE programme in the European Union, European Commission Directorate-General for Environment 2015).

Most conservation projects include outreach activities to raise the awareness of specific stakeholders, and/or the general public about biological invasions and invasive alien species (Lioy et al. 2019a). Awareness raising is a prerequisite for attitudinal and behavioral change, which could in turn foster compliance with regulations about biological invasions or the long-term endorsement of dedicated policies (Heberlein 2012). Surveys based on questionnaires are a common approach to measure awareness about biological invasions. Before-and-after designs (Novoa et al. 2017) and repeated cross-sectional designs (Russell 2014) are commonly adopted to test for temporal changes in public awareness. However, while these studies might be effective for specific stakeholders or over small spatial scales, they might fail to consider broader changes in public awareness that occur at larger spatial and temporal levels of detail. For example, while a before-and-after survey could measure changes in public awareness following a project about a particular invasive alien species, the same species might be targeted by multiple projects over a time span of several years. Designing a specific survey for this scope might be unfeasible and expensive.

On the other hand, at a time where the Internet is becoming a primary source of information worldwide, many studies showed that a growing number of people search on the Internet for those topics they are curious about, or have heard about, from various sources of information. Therefore, the analysis of online searching volumes on search engines and Wikipedia could become a valuable tool to measure public interest towards political (Mellon 2013, 2014) as well as environmental issues (Nghiem et al. 2016; Burivalova et al. 2018), including biological invasions (Cerri et al. 2020; Cerri et al. 2022). In this study, we aimed to show that it is possible to combine questionnaire-based surveys with the analysis of Internet searching volumes to draw conclusions about the awareness of stakeholders and the general public on invasive alien species by considering the case of the invasive Asian yellow-legged hornet (*Vespa velutina* Lepeletier, 1836) in Italy.

V. velutina has become invasive in Europe, where it was first reported in 2004 in France, and is increasing its distribution across Central and Mediterranean countries and in the UK (Laurino et al. 2020). From 2013 onwards, several nests of the species

have been reported in Italy, where it colonized the westernmost portion of the Liguria region, close to the French border, from which it then expanded to some areas of the Piedmont and Tuscany regions (Bertolino et al. 2016; Lioy et al. 2019b).

Apart from its impact on native insects and wild pollinators, its intensive predation upon the western honey bee (*Apis mellifera*), its reproductive potential and the lack of specialized predators, *V. velutina* can have severe impacts on beekeeping in Europe (Laurino et al. 2020). The predation of honey bees could decrease the pollination services they provide, undermine honey production and reduce the availability of individuals for the winter cluster, with consequences for the overwinter survival of the colonies (Monceau et al. 2013). The predator activity of *V. velutina* also limits the foraging activity of honey bees by promoting homing failure and determining a "foraging paralysis", where honey bees do not leave the colony fearing its predation (Requier et al. 2019), which could further reduce pollination services and honey production. *V. velutina* could also damage fruit production, as adult individuals need sweet carbohydrates to sustain their metabolism. Finally, *V. velutina*, by building nests mainly on artificial structures or trees in or near urban areas, can also be problematic due to the risk of stings to people (de Haro et al. 2010) that in some cases could lead to fatalities caused by anaphylactic reactions to stings (Feás Sánchez and Charles 2019).

The management of invasive *V. velutina* is becoming an important issue for some European countries, with France documenting an expenditure of about €23 million for nest removal in the 2006–2015 period (Barbet-Massin et al. 2020), while Spanish beekeepers from la Coruña province reported an expenditure of about €67,000 just for 2016 (Ferreira Golpe et al. 2016). The hypothetical cost for managing the species if it were to colonize all the climatically suitable areas in France, Italy, and the UK is estimated to reach about €29.5 million per year (Barbet-Massin et al. 2020).

Due to its potential impacts on beekeeping, and its associated costs, the invasion of *V. velutina* has been targeted by various conservation projects in Italy. These include the LIFE STOPVESPA (https://www.vespavelutina.eu) and the LIFE ASAP (https://www.lifeasap.eu) projects, the Aliem Interreg Med project (http://interreg-maritime.eu/web/aliem), all three projects co-founded by the European Union, and the projects VELUTINA and STOPVELUTINA (https://www.stopvelutina.it/il-progetto). While these initiatives differed in their spatial scale and specific goals, all of them included many outreach initiatives about *V. velutina*, such as press campaigns, meetings with stakeholders and workshops at beekeeping events, with the main intention of raising the awareness of both beekeepers and laypeople.

The aim of the present study was to investigate public awareness about the invasive hornet *V. velutina* in Italy by implementing two different approaches for analyzing i) how beekeepers perceived the impact of the species, and ii) how online searches on *V. velutina* varied over time. Therefore, we first administered a questionnaire to a sample of beekeepers in Italy to ask them about their perception of *V. velutina* and its impact (also in relation to the other threats affecting honey bees) and their primary sources of information about the species. Then, we conducted a time-series analysis to identify long-term trends in on-line searches on Google and Wikipedia about *V. velutina* in Italy to capture temporal trends in public awareness about the species.

Methods

Questionnaire design and administration

In August 2019, we designed a questionnaire on GoogleForms, to measure beekeepers' perception of *V. velutina* as a threat to beekeeping and the conservation of honey bees. The questionnaire was divided into four different sections for measuring: i) the primary sources of information about *V. velutina* adopted by the beekeepers, ii) the perceptions about the most significant impacts of *V. velutina* on beekeeping and human activities, iii) the severity of *V. velutina* as a threat to beekeeping, compared to other major threats, and iv) the characteristics of respondents and their beekeeping activity.

Information sources were evaluated by asking respondents to complete a check-box with some of the main types of traditional and digital media: the Internet, newspapers, television or radio, specialized magazines, beekeeping bulletins, social networks, mailing lists, word-of-mouth with other beekeepers, communication with agronomists or entomologists, beekeeping workshops and significant beekeeping events (e.g. showrooms, conventions).

The main impacts of *V. velutina* that we mentioned in the questionnaire included a reduction in honey production caused by predation on honey bees and the inhibition of foraging, decrease in honey bees for the winter cluster, disease transmission to honey bees by foraging upon multiple colonies, damages to fruit orchards, increased risk of stings for the beekeepers. Moreover, we asked whether the impact of *V. velutina* was greater than that of the native European hornet (*Vespa crabro*). We asked for respondents' agreement with a series of statements about these impacts on a 5-point bipolar scale, ranging from "Totally disagree" to "Totally agree". As respondents may not have been familiar with some of the impacts, questions also had an "I don't know" option.

Then we asked respondents about which were the main threats to beekeeping, in their opinion. These included honey bee predation by *V. velutina*, predation by native Hymenoptera, predation by birds, pesticide poisoning, infestation by the small hive beetle (*Aethina tumida*), infestation from the varroa mite (*Varroa destructor*), nosemosis or fungal, bacterial and viral diseases. Each of these threats was evaluated on a 5-point unipolar scale, ranging from "Not serious at all" to "Extremely serious".

In the final section, we asked respondents whether they came from an area that had already been invaded by *V. velutina*, the decade when they started beekeeping, the size of their apiary, their sex, age and level of education, as well as the location (at the district level) where they practice beekeeping.

Questionnaires were forwarded to a sample of beekeepers in Italy, both from invaded and non-invaded areas, through a snowballing approach. Researchers who already operated in the management of *V. velutina* contacted referents from beekeeping organizations, asking them to forward the questionnaire to their contacts. This approach was chosen because a representative sample was not achievable with other techniques due to the absence of complete data about single beekeepers and the impossibility of designing a sampling strategy to recruit them in the field because of their different habits and the spatial scale of the study. A complete copy of the questionnaire in English and Italian language is available in Suppl. material 1.

Analysis of Google Trends and Wikipedia data

To measure whether there was an increase in public awareness about *V. velutina* through time, in Italy, we explored the temporal evolution of the volume of searches on Google about the Italian name for the species "*Calabrone asiatico*" (literally, Asian hornet, in Italian) and also the scientific name "*Vespa velutina*", which has become widely adopted. Moreover, we also explored the temporal evolution in the monthly number of visits to the Wikipedia page "*Vespa velutina*" since 2015.

Google Trends is a relative index obtained by dividing the total number of searches related to a specific query by the total volume of searches on Google. The index is then rescaled between 0 and 100 by assigning the maximum value (100) to the point of the time series with the highest value of the index. Therefore, Google Trends is a relative metric, which is strongly discounted for the increasing number of searches on Google over time. On the other hand, the WikiMedia foundation allows users to access the number of visits, expressed as a raw count, to the various pages of Wikipedia, at least since July 2015. The combined use of Google Trends and Wikipedia visits therefore enabled us to both identify whether searches for *V. velutina* had become more common through time, as well as to appreciate their order of magnitude.

Data analysis

To highlight differences in beliefs about the impacts of *V. velutina* between respondents from the invaded and the non-invaded range of the species, as well as in its perception as a threat to beekeeping, we compared the distribution of answers using the Potential for Conflict Index (PCI, Vaske 2018) and a chi-square test of independence. To be consistent with analysis of Google Trends data, we adopted a Bayesian implementation of the chi-square test, based on the Bayes factor. The Bayes factor essentially assess the odds of the alternative hypothesis of an association between two variables, over the null hypothesis of independence. We ran the Bayesian test of association with the BayesFactor package (Morey and Rouder 2021) using default priors and Poisson sampling plan, as the number of subjects had not been fixed in advance. The PCI is a common measure of respondents' polarization in human dimensions studies adopted in surveys with bipolar or unipolar scales, ranging between 0 and 1. The minimum value of the PCI indicates the maximum agreement between respondents, when their answers lie entirely on the same point of the scale, while the PCI peaks when respondents are equally divided between the two opposite points of the scale. Moreover, we tried to segmentate respondents according to their sources of information about *V. velutina*, through a hierarchical cluster analysis.

Online searches on Google, based on the Google Trends index, were converted on a logarithmic scale, then decomposed in their long-term trend and their seasonal component, based on Bayesian structural time series with a Gaussian distribution of the error, a state-space model for time-series data (Scott and Varian 2013). Statistical analyses were carried out with the statistical software R (R Core Team 2020).

Data resources

Datasets and reproducible software code are available at https://osf.io/efs7k/.

Results

Structured questionnaire

Overall, we collected 358 surveys from our sample of beekeepers. Most respondents (59.7%) came from Liguria, Piedmont and Tuscany, regions that had already been invaded by *V. velutina*, while the remaining beekeepers from uninvaded regions, almost entirely in Central and Northern Italy (Fig. 1). Most respondents were men (82.3%), with a higher education (86.0%) and an age between 36 and 65 years (18–25 years = 2.8%, 26–35 years = 13.4%, 36–45 years = 28.2%, 46–55 years = 27.4%, 56–65 years = 17.0%, over 65 years = 11.2%). The majority of respondents started beekeeping after 2010 (62.0%) or in the early 2000s (16.5%) and had a small apiary (5 colonies or fewer = 26.8%, 6–10 colonies = 27.7%, 11–25 colonies = 25.1%, 26–50 colonies = 8.9%, 51–100 colonies = 5.6%, more than 100 colonies = 5.9%).

Beekeepers apprised themselves about *V. velutina* from multiple sources of information, in particular beekeeping workshops (53.4%), specialized journals (51.4%), the Internet (49.2%), beekeeping bulletins (42.5%), word-of-mouth with other beekeepers (37.7%) and agronomists/entomologists (36.3%), beekeeping events (20.9%), social networks (19.3%), generalist newspapers (17.6%), television or radio shows (14.0%) and mailing lists (6.1%). Hierarchical cluster analysis did not identify any major cluster of respondents, but instead 10–11 small clusters whose differences were unclear.

Most respondents believed *V. velutina* to have major impacts on honey bee colonies, mostly by reducing honey production through bee predation and foraging paralysis, and by decreasing the size of winter clusters. Moreover, respondents believed that *V. velutina* could increase the risk of stings to beekeepers and that its impacts were more severe than those of the native European hornet (*V. crabro*) (Fig. 2). On the other hand, respondents were less certain about the potential role of *V. velutina* in disease transmission to honey bees by foraging over multiple colonies.

Respondents from invaded areas were more certain than those from uninvaded areas that *V. velutina* represents a severe threat to honey bees because of its foraging behavior (Bayes factor (*BF*) for the test of association of 116:1). The *BF* indicated that the odds of the alternative hypothesis of an association between these two variables was 116 times more likely than the null hypothesis of no association. For the other impacts, no differences were observed between respondents from the invaded and uninvaded range (BF_{10}: honey availability = 0.04; winter cluster = 0.47; fruit production = 0.04; disease transmission = 0.25; risk of stings = 0.08; European hornet = 0.73).

V. velutina was considered a severe threat to honey bees and beekeeping. Respondents from invaded areas assigned it a severity score comparable to pesticides or the varroa mite (*V. destructor*) (Fig. 3). Moreover, respondents from the invaded areas were

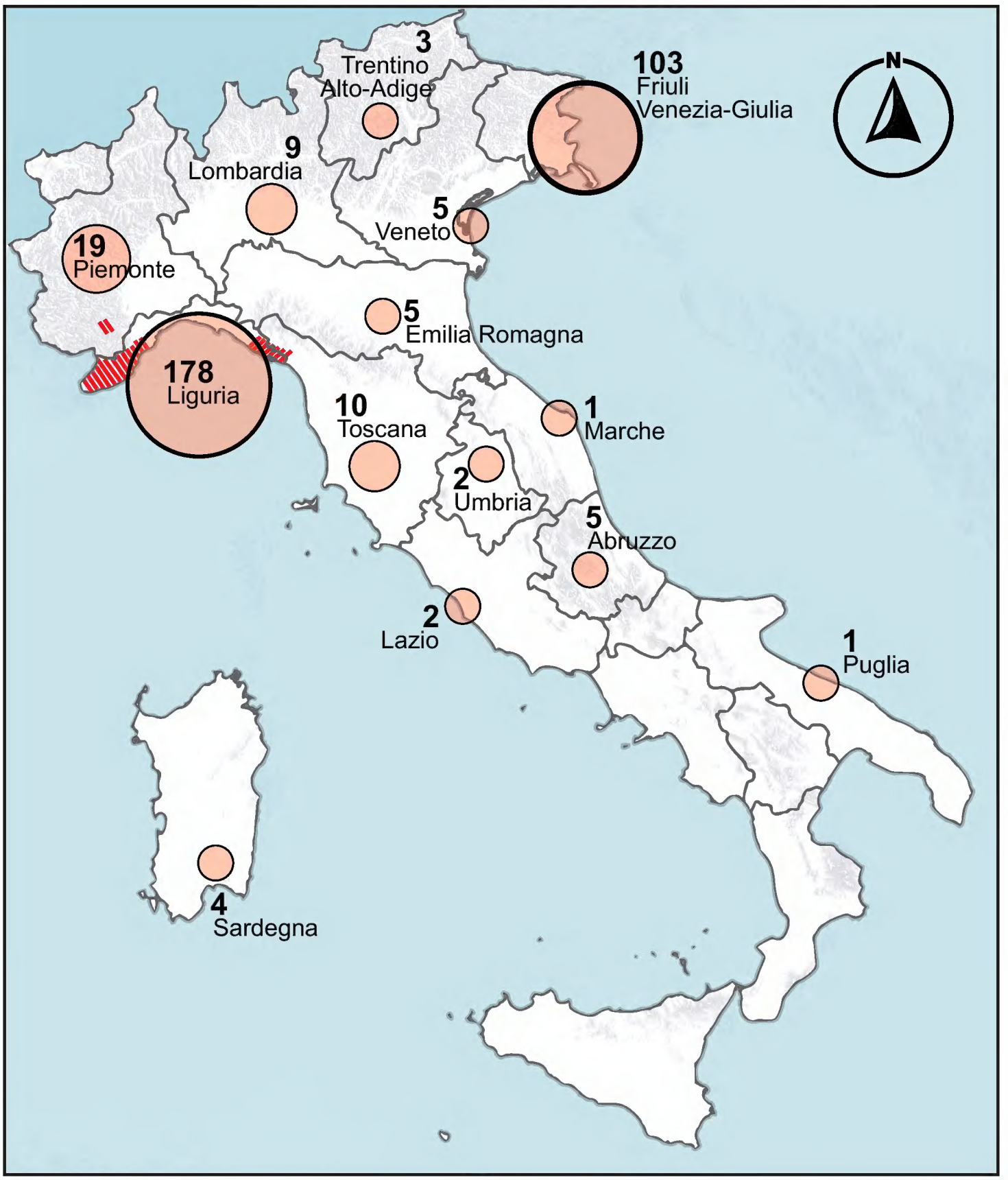

Figure 1. Geographical distribution of respondents between the various Italian regions. Dashed areas correspond to the invaded range of *V. velutina* in Italy, in the Piemonte, Liguria and Toscana regions. Numbers above region names correspond to the number of respondents in each region. Circle areas were assigned arbitrarily to represent differences in the number of respondents between regions. 11 respondents did not indicate their region.

more certain that *V. velutina* poses a serious threat to honey bees than respondents from uninvaded areas (BF_{10} = 26). For the other threats to beekeeping, no differences were observed between respondents from the invaded and uninvaded range (BF_{10}: pesticides = 0.002; native Hymenoptera = 0.15; birds = 1.47; *Aethina tumida* = 0.10; bacterial diseases = 0.05; *Nosema apis* = 0.08; fungal diseases = 0.03; viral diseases = 0.03;

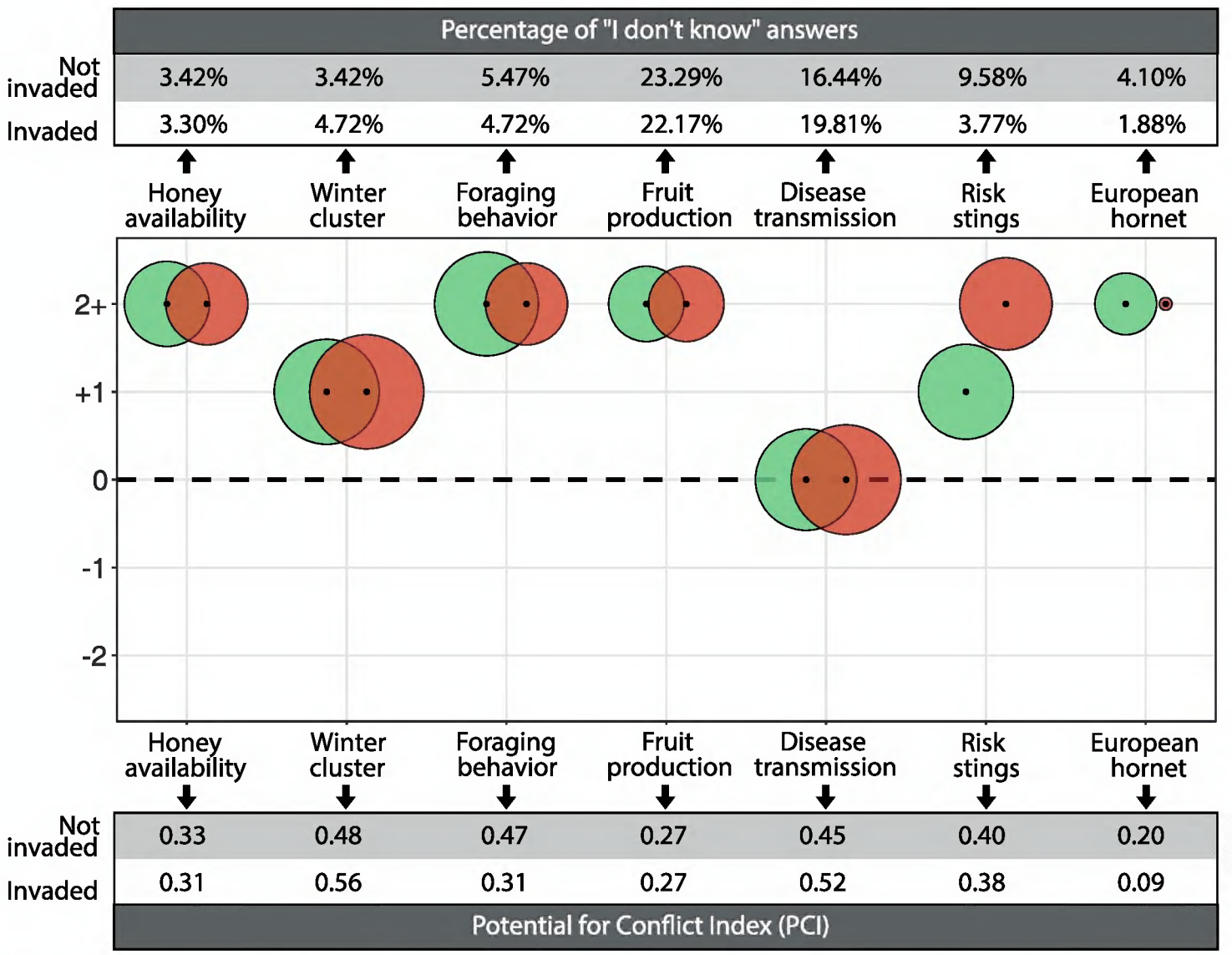

Figure 2. Perceived impacts of *V. velutina*. Comparisons of the perceived impacts between respondents from the invaded and the non-invaded range of the species. Answers were measured on 5-points of a bi-polar scale (y-axis), ranging from "Strongly disagree" (-2) to "Strongly agree" (+2). Bubbles were centered on the median score of invaded and non-invaded areas, and their size was proportional to the Potential for Conflict Index, which ranged between 0 (no disagreement, all answers on the same point of the scale) and 1 (respondents were equally divided between the two opposite points of the scale). Bubbles on the left (in green) represented answers from respondents living in non-invaded areas, while bubbles on the right (in red) answers from respondents living in invaded areas.

Varroa destructor = 0.03). The distribution of scores to the questions on the perceived impacts of *V. velutina* and its severity in relation to various threats for beekeeping is available in the Suppl. material 2.

Analysis of Internet searching volumes

The Google Trends index for the queries "*Calabrone asiatico*" and "*Vespa velutina*" showed clear seasonal fluctuations, with a high number of searches between April and October, corresponding to the activity period of *V. velutina*. Searches usually had two peaks per activity period. Moreover, the two queries had an increasing long-term trend in their number of searches on Google. Notably, while the volume of searches for "*Vespa velutina*" mostly increased until summer 2015 and then stabilized, the query "*Calabrone asiatico*" increased steadily through time (Fig. 4).

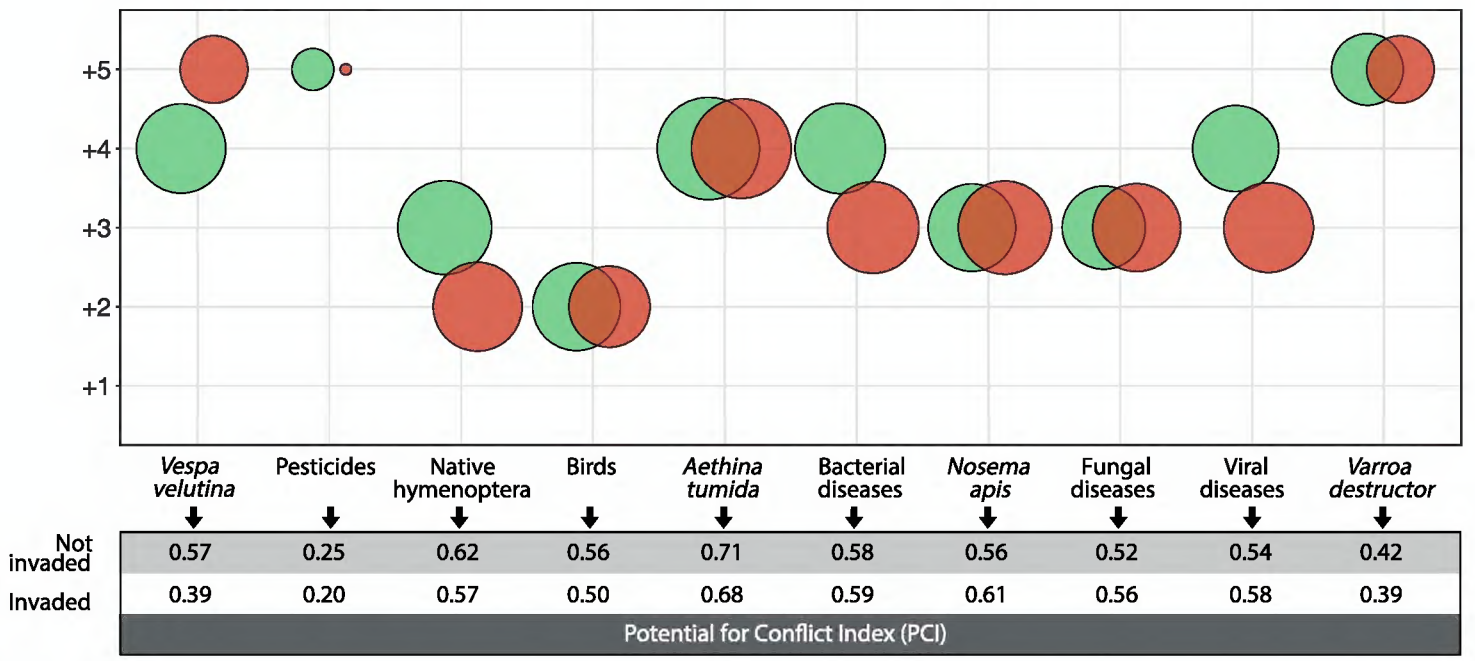

Figure 3. Perceived severity of various threats for beekeeping. Comparisons between respondents from the invaded and the non-invaded range of the species. Answers were provided on a unipolar scale ranging from "Not at all serious" (+1) to "Extremely serious" (+5) (y-axis). Bubbles were centered on the median score of each answer, and their size was proportional to the Potential for Conflict Index, which ranged between 0 (no disagreement, all answers on the same point of the scale) and 1 (respondents were equally divided between the two opposite points of the scale). Bubbles on the left (in green) represented answers from respondents living in non-invaded areas, while bubbles on the right (in red) represented answers from respondents living in invaded areas.

The monthly number of visits to the Italian Wikipedia page for *V. velutina* was quite high and variable (median ± sd = 2503 ± 3042), but it showed a similar seasonal pattern, with visits increasing between April and October and being characterized by a double peak in this timespan (Fig. 5).

Discussion

To the best of our knowledge, this study constituted a first attempt to draw conclusions about the awareness of beekeepers and citizens towards *V. velutina* in an invaded area of Europe. While another study (Requier et al. 2020) explored the behavior of beekeepers in response to *V. velutina*, no study formally asked beekeepers about their beliefs on the potential impacts of *V. velutina*, or about its potential magnitude with respect to other threats that could affect honey bees and beekeeping activity. Taken together, findings from the questionnaire for the beekeepers and the analysis of Internet searching volumes, indicate that public awareness increased over the years after the detection of the species in Italy, and that stakeholders are aware about the invasion of *V. velutina* and its social and ecological impacts. The different conservation projects developed in Italy over the years may have contributed to achieving these results, together with dissemination activities by beekeeper associations and by the media in general.

Beekeepers in Central and Northern Italy seem to have received considerable exposure to news concerning *V. velutina* and its potential environmental and socio-economic

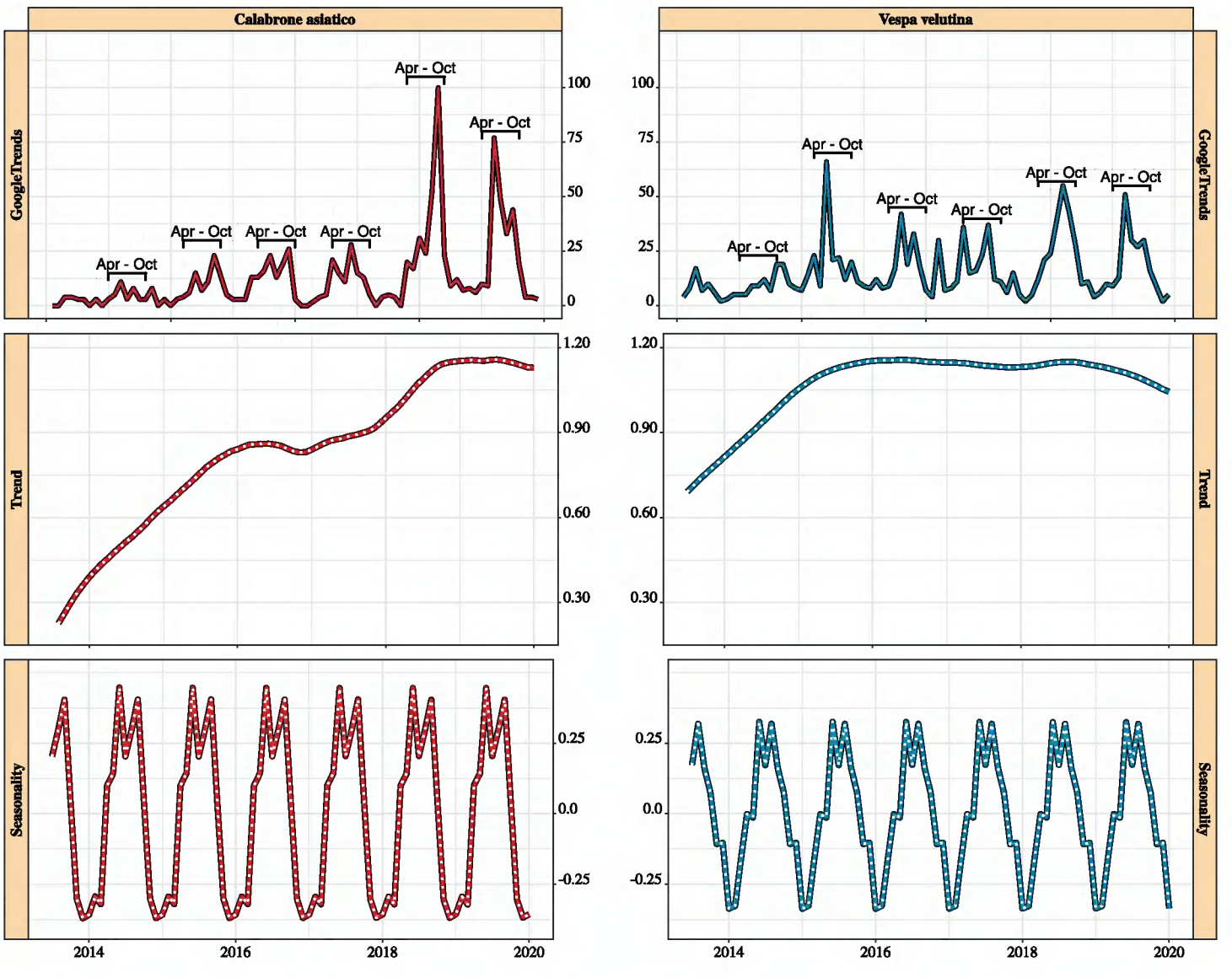

Figure 4. Volume of searches on Google. Volume of searches for the queries "*Calabrone asiatico*" and "*Vespa velutina*", the two Italian words mostly used for naming the species. Google Trends index (top), long-term trend (center) and seasonal component (low) of the log-converted Google Trends index.

impacts. Such exposure, in turn, affected their concerns about the species. The vast majority of our sample believed that *V. velutina* could have detrimental impacts on the conservation of honey bees and beekeeping, in line with the available scientific evidence (Requier et al. 2019; Laurino et al. 2020). Respondents from invaded areas seemed to be even more concerned about this. They believed *V. velutina* to have greater impacts than the native *V. crabro*, another species that could prey on honey bees. Moreover, these impacts were also considered relevant for beekeeping and the conservation of honey bees. *V. velutina* severity was considered comparable to that of other major causes of honey bee decline, such as pesticides (Sánchez-Bayo et al. 2016; Tsvetkov et al. 2017) or *Varroa destructor* (Thoms et al. 2019), and even more severe than other stressors, such as the predation from other native Hymenoptera, or viral, fungal and bacterial diseases. While our findings came from a convenient sample of beekeepers, which may have been more in contact with beekeeping organizations and more aware than the "average" beekeeper, we believe our findings to be strong enough that it is unlikely that the scenario from the overall beekeeping community is very much different. *V. velutina* seems to be considered a species with systematic and not-negligible impacts on honey bees and beekeeping.

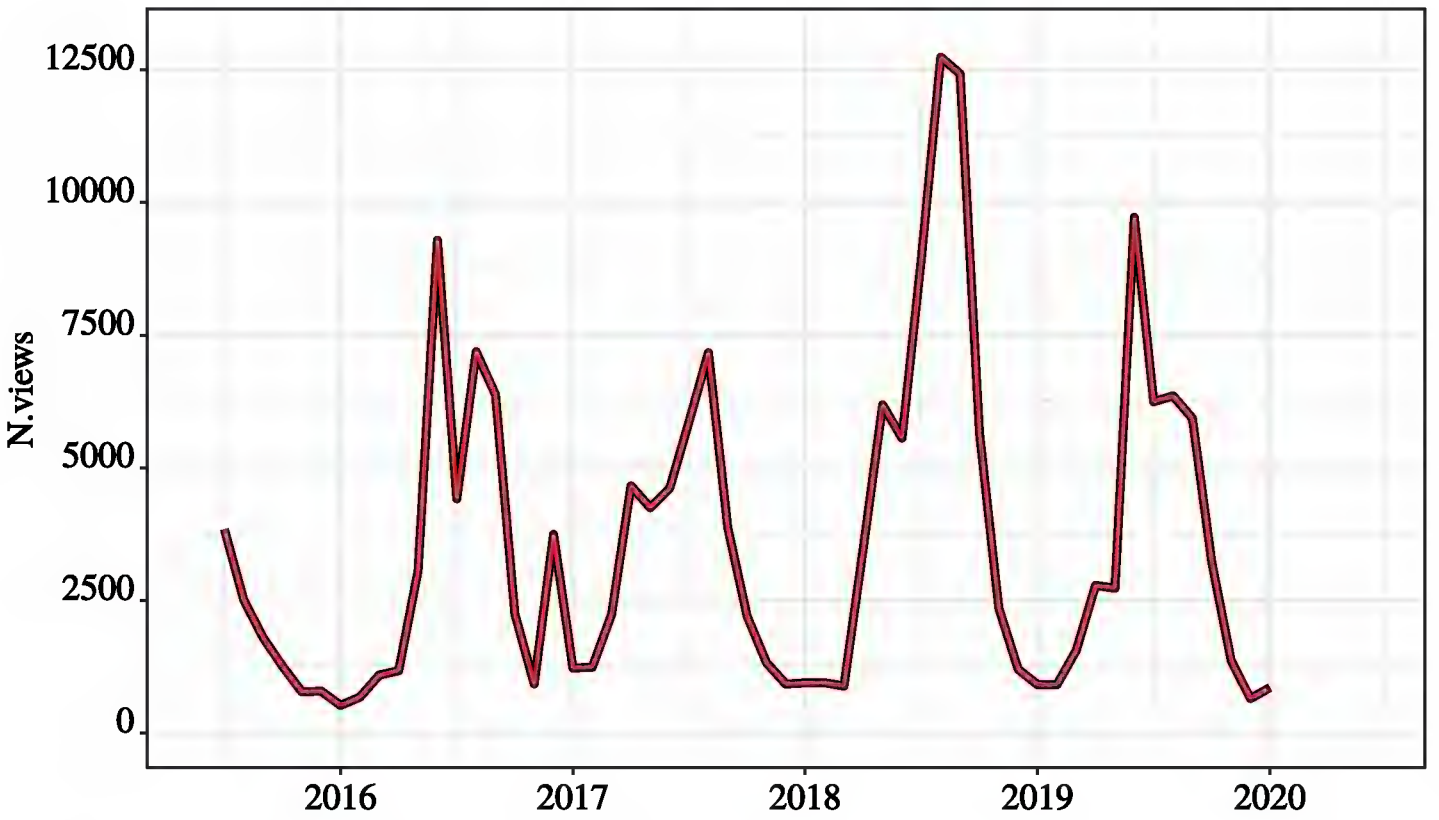

Figure 5. Volume of searches on Wikipedia. Temporal evolution of the monthly number of visits to the Wikipedia page "*Vespa velutina*", in Italy, over the last few years. The time series starts in July 2015.

Moreover, we found that beekeepers apprised themselves about *V. velutina* from a wide range of different channels, encompassing both the Internet and specialized magazines, and also activities with other members of their community, like other beekeepers and professionals holding workshops. On the other hand, conventional media and mailing lists seemed to be minor information sources on *V. velutina*.

These findings might help to design communication campaigns about *V. velutina* among beekeepers. The fact that beekeepers seem to be at least familiar with the species and its impacts indicate that they might have stable attitudes about this topic (Heberlein 2012). Their involvement in ongoing management initiatives confirms this. Both LIFE STOPVESPA and STOPVELUTINA projects have seen the participation of many beekeepers in the monitoring of *V. velutina* distribution (see projects website). The awareness of the impact caused by *V. velutina* and the willingness to collaborate in its management is fundamental for the extension at the national scale of an Early Warning and Rapid Response system already developed in the invaded area (Porporato 2016). Considering the sources of information that are adopted the most by beekeepers, conservationists should further promote participation in management activities through peer-to-peer communication within the beekeeping community, by publishing papers on specialized magazines and advertising on Internet sites about beekeeping, decreasing their expenditures for communication campaigns on traditional media. Italy hosts approximately 40,000 amateur and 18,000 professional beekeepers, and their engagement in rapid detection and early warning activities could be fundamental to monitor the species at the national scale.

The seasonality of Internet searches about *V. velutina* seems to be correlated with the phenology of the species, since online searching volumes increased when people can observe the species in the environment (Mittermeier et al. 2019). Searches on Google increased during the activity season of the species, between April and October, with two peaks in May-June and August-September, corresponding to the first phase of nest construction and to the time of the year when colonies reach considerable size, becoming a concern for people. However, the observed seasonality could also be affected by the news published by the media or by ongoing conservation projects, which seems to have a higher frequency during the months of activity of the species (Lioy et al. 2019c).

Consultation to the Wikipedia page about the species was in the order of thousands of visits per month, with peaks of more than 10,000 visits. We believe that such a high number of visits is unlikely to have been generated by stakeholders or researchers alone, and that it probably involved laypeople as well. The overall volume of Internet searches about *V. velutina* and their long-term trend indicated a progressive awareness of laypeople about its progressive establishment into new areas and related consequences. This aspect was confirmed by the long term-trends of the Google Trends index for the two Italian words for the species, which increased between 2013 and 2020, reflecting the progressive spread of the species in Italy and the emergence of relevant impacts on beekeeping (Bertolino et al. 2016). The Google Trends index is discounted for the overall number of searches on Google, which strongly increased between 2013 and 2020 (Bologna et al. 2018): the fact that such index grew steadily during this period indicates that a growing proportion of people were interested in *V. velutina* and searched for it on the Internet.

The analysis of Internet searching volumes might be a promising complementary tool for monitoring the presence of *V. velutina* in Italy and Europe. As Google Trends can be downloaded at the regional level, peaks in searches about *V. velutina* could signal the species' colonization of a certain area. This approach is already adopted in epidemiology to trace the circulation of viral disease (Carneiro and Mylonakis 2009), and other studies considered it for the monitoring of common invasive alien species, such as the tiger mosquito (*Aedes albopictus*, Cerri and Bertolino 2020). As *V. velutina* actively exploits human buildings for constructing its nests, becoming visible and concerning to residents, this approach should work well in its invaded range due to the high proportion of urban and rural landscapes. Nevertheless, due to the high misidentification rate of the species with native insects, peaks in searches should be followed by insights or direct monitoring with traps (Demichelis et al. 2014; Lioy et al. 2020) for assessing with certainty the presence of *V. velutina*. Moreover, the analysis of seasonal patterns in relation to searches on Google and Wikipedia might also highlight spatial patterns in the phenology of the species in its invaded range, contributing to improve our understanding of how the phenological plasticity of invasive alien species affects their invasion success at a time of climate change (Manfredini et al. 2019).

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Supplementary material 1

Complete copy of the questionnaire on *Vespa velutina* in English and Italian language

Authors: Jacopo Cerri, Simone Lioy, Marco Porporato, Sandro Bertolino

Data type: PDF document

Explanation note: Complete copy of the questionnaire on *Vespa velutina* in English and Italian language.

Link: https://doi.org/10.3897/neobiota.73.80359.suppl1

Supplementary material 2

Distribution of scores to the questions on the perceived impacts of *V. velutina* and its severity in relation to various threats for beekeeping

Authors: Jacopo Cerri, Simone Lioy, Marco Porporato, Sandro Bertolino

Data type: PDF document

Explanation note: Distribution of scores to the questions on the perceived impacts of *V. velutina* and its severity in relation to various threats for beekeeping.

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